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REPORT

Project ID: AQEA-17-0225
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A Final Report Prepared For:

CLIENT	Liberty Dairy, LLC 5860 E. Zillah Drive Granger, WA 98953 USA		
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SUBJECT	"Leak Detection Service For Conducting A Monitoring Survey For H&S Bosma Consolidated Lagoon 15 Located At Liberty Dairy Farm Facility In Granger, Washington, USA"		

Dear Client,

On June 16th of 2018, Harvey Moy of Beyond Leak Detection (BLD) conducted a monitoring survey with the Permanent Electrical Leak Monitoring (PELM®) System for H&S Bosma Consolidated Lagoon 15 (HS-CL15) located at Liberty Diary Farm Facility in Granger, Washington, USA. HS-CL15 had a geoelectric survey and installation area of approximately 51,300 square feet. The installation of the PELM® System was performed in the subgrade prior to placement of geosynthetic layers during September of 2017. The PELM® System contained an array of electrodes with an oriented, grid platform spacing of 50 feet by 50 feet, or hereinafter, the PELM5050 System.

After the geosynthetic layering system was installed for HS-CL15, the lagoon had a final cross-sectional construction layout, from the top surface layer, with:

- single 40-mil high-density polyethylene (HDPE) smooth geomembrane liner
- geosynthetic clay liner (GCL)
- partial/sectional areas of geonet
- prepared subgrade

The level of liquid in HS-CL15 had a vertical depth of approximately 14 feet while functioning at maximum operating capacity. This report documents the results of the leak detection services performed by BLD.

SECTION 1 - INTRODUCTION

1.01 PELM5050 SYSTEM METHODOLOGY

The PELM5050 System can easily test the integrity of a geomembrane by locating penetrations on the geomembrane. This is accomplished by impressing an excitation voltage between the material above and below the geomembrane with two separate current electrodes. Then electrical potential measurements are collected underneath the geomembrane and referenced to stationary electrodes. Therefore, the geomembrane provides an electrical barrier or isolation between the two current electrodes except where there are leaks or damages in the geomembrane. Electrical current flowing through the leaks in the geomembrane produces localized anomalous areas of high current density near the penetrations, which are detected by potential measurements below the geomembrane. A single channel memory earth resistivity meter and switch box is used to collect the potential measurements or data relative to the geomembrane at measurement stations. After data collection from the meter at the measurement stations is complete, the data is downloaded to a computer for plotting and data analysis. Figure 1 shows a typical interface setup at the measurement station during the PELM® survey.

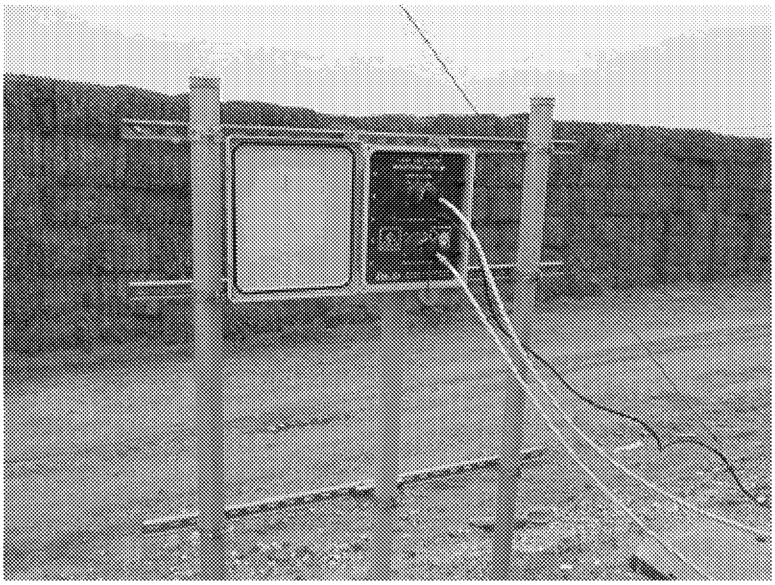

Figure 1. A Typical Interface Setup with the Resistivity Meter at the Measurement Station during the PELM® Survey

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SECTION 2 - THE LEAK MONITORING SYSTEM

2.01 GENERAL COMPONENTS

The installation of the PELM5050 System consisted of multiple components that can withstand harsh environments. These components were installed according to the specifications in the proposal for HS-CL15. In summary, the components of the PELM5050 System included:

- Direct Burial Wires
- Stainless Steel Electrodes (sensor, artificial leak, and reference)
- Stainless Steel Hardware (screws, washers, nuts, and terminals)
- Disconnect Junction (DJ) Boxes
- NEMA Rated Enclosure Control Panels with Artificial Leak Unit (consists of military industrial connectors, test leak switch box, and terminals)
- Resistivity Meter (SuperSting R1/R8 and 84-Electrode Switch Box)
- Leak Detection Software, or the Potential Measurement Analysis Tool 2017

The maximum distance to from each sensor electrode was approximately 50 feet. To test the sensitivity of the monitoring system, four artificial leak electrodes were installed at different distances. Table 1 lists the distances of the artificial leaks from a nearby sensor electrode.

ARTIFICIAL LEAK	DISTANCE (FT)
1	1
2	12.5
3	25
4	35.36

Table 1. List of Artificial Leaks and Distances from Nearby Sensor Electrodes

2.02 RESISTIVITY METER AND SWITCH BOX

The unit used to collect data and energize the PELM5050 System was a multi-channel earth resistivity meter, or the SuperSting R8 (SSR8). Only the single-channel functionality was used during the surveys. The meter collects potential measurements through one channel for each measurement cycle, and has the capability to communicate with an Android device during field usage. The meter was connected to a switch box that switches from 84 different electrodes. The system was powered by a deep-cycle 12 volt battery. Figure 2 shows an example of a typical setup of the resistivity meter and switch box during data collection from inside a vehicle. Data collection was downloaded to a PC via SuperSting software and analyzed using the leak detection software.

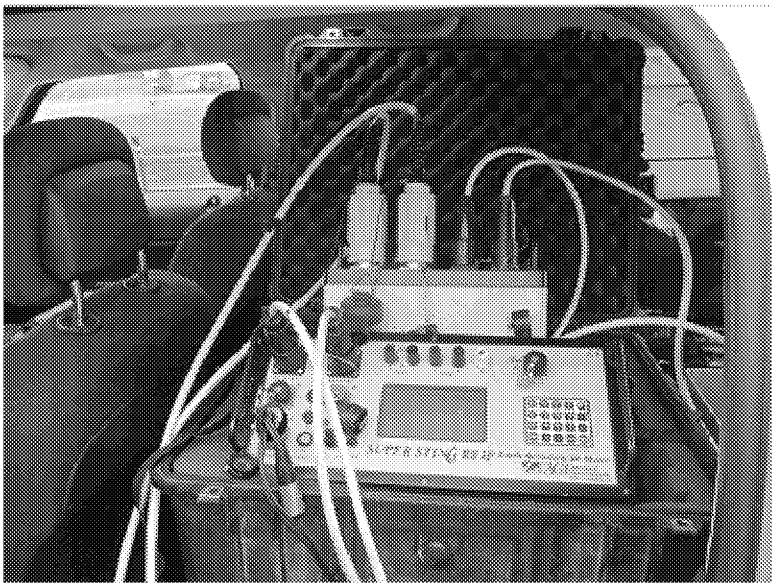

Figure 2. Typical Setup of Resistivity Meter and Switch Box in Vehicle

2.03 SOFTWARE

After data was collected in the field using the resistivity meter, it was downloaded to a computer using the SuperSting Control Center Software (Administrator) and analyzed with the leak detection software analysis tool, or Potential Measurement Analysis Tool 2017 (PMAT17). PMAT17 is a custom made web-based software that allows Client to easily load and analyze data files from the resistivity meter that were collected from the field. The Wi-Fi required software displays a topographic map of the application, all sensor electrodes, resistance values, and the coordinates of each sensor location. Three colors are displayed to categorize each sensor electrode in the PMAT17 software: red, green, and gray. "Red" signifies a positive anomaly or penetration in the cell (investigation will be required), "Green" represents a valid normal potential measurement that did not exceed the leak threshold, and "Gray" informs the user or technician that the data collected from this particular sensor was erroneous and not valid. This may be due to a disconnect with the sensor electrode due to a break or damage, or insufficient level of saturation surrounding the electrode.

2.04 SYSTEM LAYOUT

The PELM5050 System at HS-CL15 consisted of 32 potential or sensor electrodes. The cell contained two reference electrodes, four artificial leak electrodes, and one measurement station. The measurement station at the facility was labeled as Measurement Station "A" (MS-A), and required only one DJ box with one control panel. A portable, source electrode was used as the current injection of the PELM5050 System. Figure 3 shows the map of electrodes and measurement station of the PELM5050 System at HS-CL15.

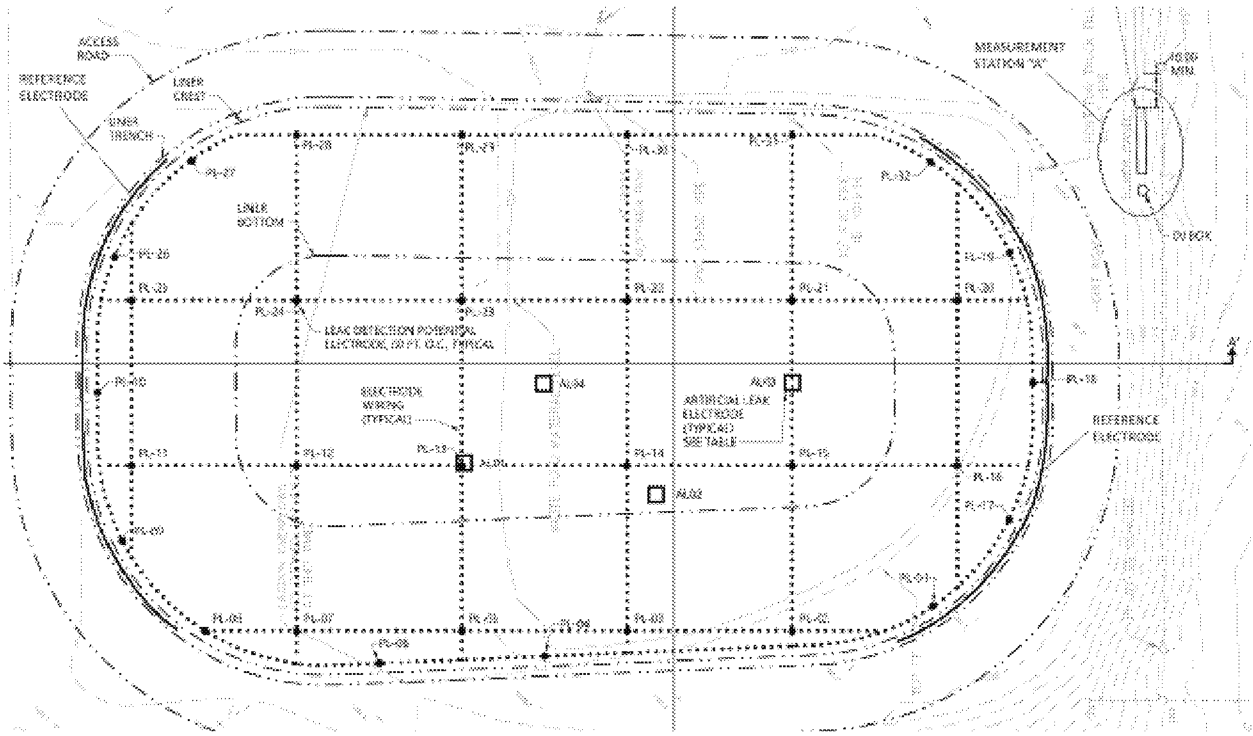

Figure 3. Map of the Locations of Electrodes and Measurement Station "A" of the PELM5050 System for HS-CL15 at Liberty Dairy Farm Facility

2.06 RESULTS

A. Power Settings

For data collection at HS-CL15, the high voltage setting was 400 Volts. The current settings for Table 2 was configured during the survey process. The lagoon contained liquid at maximum operating capacity with a vertical depth of approximately 14 feet. Current settings may change over time depending on multiple factors such as environmental change, liquid conductivity, and/or ground interferences.

DATA COLLECTION TYPE	CURRENT SETTING (mA)
RAW	50
ARTIFICIAL LEAK 1	50
ARTIFICIAL LEAK 2	50
ARTIFICIAL LEAK 3	50
ARTIFICIAL LEAK 4	50

Table 2. Current Settings for Data Collection for HS-CL15 at Liberty Dairy Farm Facility

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B. Leak Threshold Limit Value

Because actual leaks were not used in the PELM5050 System, the leak threshold limit (LTL) was derived from the previous artificial leak calibration process. To determine the current LTL value for HS-CL15, the artificial leak electrodes were energized and connected to the current source. The nearby sensor electrodes where the potential measurements were collected at each artificial leak contained an overall, low resistant value that varies during each calibration process. The polarity of the value is determined by the current flow. Under normal data collection, the potential from the electrodes are measuring the resistance and current flow to the ground electrode. When a potential anomaly has been introduced, the current flow will redirect and flow towards the anomaly since it represents a positive energy source of the cell. The current flow of negatively charged electrons will channel to the least resistive path towards the anomaly. Since the anomaly, or a confirmed leak in the geomembrane, has a dense amount of protons surrounding the leak, electron flows toward the leak and the resistance is measured. The resistivity meter collects data with a 2% error (% error may vary), therefore, the LTL value for the PELM5050 System at HS-CL15 is currently set to -0.01007 ohms (–10.07 milliohms). This value is the lowest LTL value thus far when compared to previous LTL values for HS-CL15. The LTL value may change over time depending on multiple factors such as environmental change, liquid conductivity, and/or ground interferences.

C. Data Collection of Artificial Leaks

When analyzing data on the PMAT17 leak detection software, a topographical picture is displayed and outlines the approximate cell perimeter. All sensor electrodes are positioned according to the survey coordinates provided during installation of the system. If any sensor electrodes were recorded below the LTL value, then this would visually notify the user that a potential anomaly may be present via red sensor electrode. In this case, further investigation would be required. The artificial leak electrodes are not displayed on PMAT17 since they are energized sources, and therefore, not used as potential measurement electrodes or devices. Figure 4 shows an example of an artificial leak approximately 1 foot away from a nearby sensor electrode when the artificial leak is energized during the Artificial Leak Test.

All data collected while energizing all artificial leaks displayed the correct functionality and sensitivity of the PELM5050 System. The calibration procedure demonstrated that all artificial leaks were active during data collection. Table 3 lists the energized artificial leaks, their respective nearby sensor electrodes, and the potential measurements.

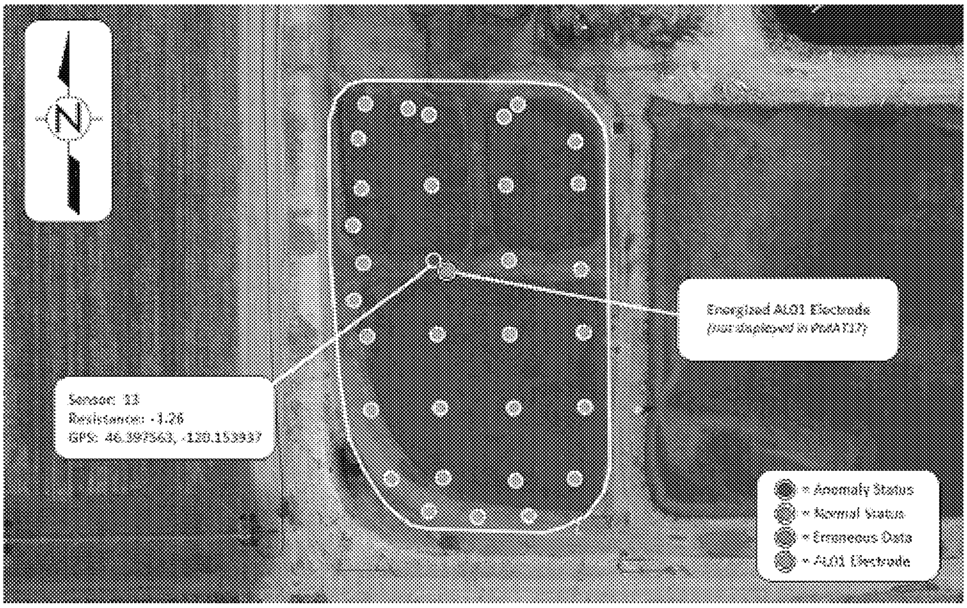

Figure 4. Example of a Sensor Electrode (Sensor 13) Displaying an Anomaly Status (Red) when an Artificial Leak (AL01) is Energized

ARTIFICIAL LEAK	SENSOR ELECTRODE	RESISTANCE *(Ohms)*
1	13	-0.14178
2	14	-0.03933
3	15	-0.01148
3	21	-0.01009
4	13	-0.02349
4	14	-0.02344
4	22	-0.03913
4	23	-0.03912

Table 3. List of Energized Artificial Leaks, Nearby Sensor Electrodes, and Potential Measurements for HS-CL15 at Liberty Dairy Farm Facility

D. Data Collection of Raw Set

The PELM® Survey required multiple data collections using the resistivity meter without enabling or activating the artificial leaks. "Noisy" data, or false, inaccurate measurements or readings that are collected due to ground noise interference or resistivity, may be present in some raw data collections. BLD recommends three sets of data collection during any PELM® Survey to verify the consistency during raw data collection. This will ensure that data collected during a normal survey are not mistaken as potential anomalies, or false positives.

During the raw data collection process at HS-CL15, all raw data sets showed no suspects of potential anomalies. The data collection was performed with a high voltage output of 400 Volts, and a current setting of 50 milliamps. Currently, this verifies that the liquid in HS-CL15 is contained and that the integrity of the geomembrane has not been compromised. Table 4 lists the raw set of data collected at MS-A and the resistance value of each sensor electrode. Figure 5 shows the map of electrodes with normal status using PMAT17 for HS-CL15.

SENSOR ELECTRODE	**RESISTANCE *(Ohms)***	**SENSOR ELECTRODE**	**RESISTANCE *(Ohms)***
1	9.45999	17	1.76929
2	2.91887	18	1.64835
3	2.95321	19	1.68201
4	2.95311	20	1.64867
5	3.01631	21	1.74854
6	2.93475	22	1.73749
7	2.99955	23	1.78606
8	3.04555	24	1.85034
9	3.31054	25	2.10825
10	3.37958	26	2.18529
11	3.21829	27	1.86481
12	2.93056	28	1.78097
13	2.90328	29	1.74237
14	2.91745	30	1.72167
15	2.86192	31	1.70036
16	2.86192	32	1.66593

Table 4. Raw Set of Data Collection at MS-A for CL15 at Liberty Dairy Farm Facility

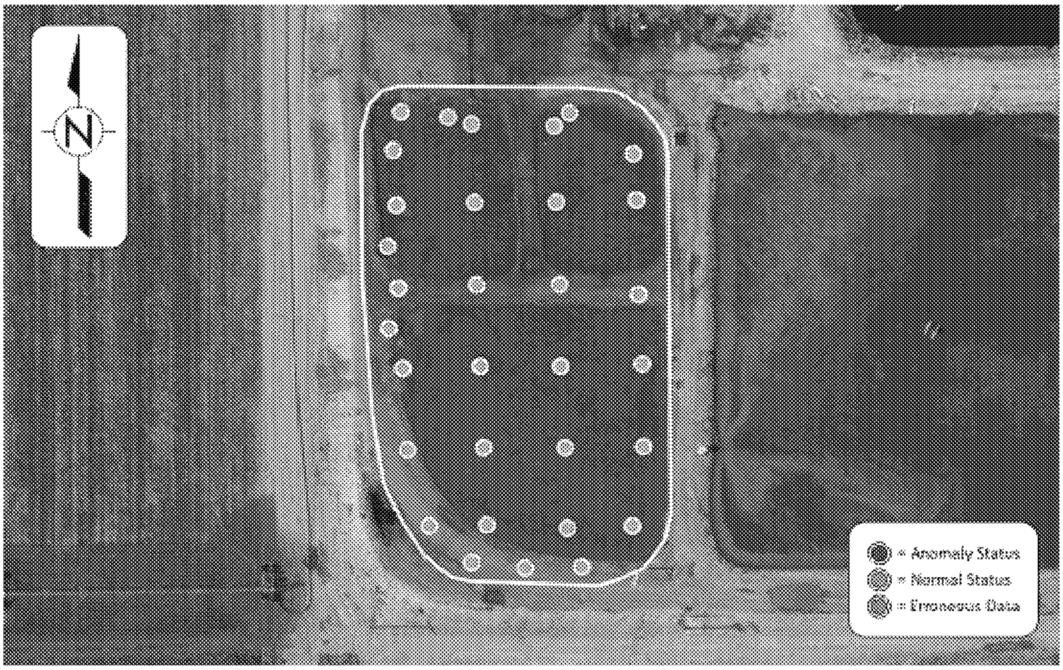

Figure 5. Sensor Electrodes at MS-A with Normal Status for HS-CL15 at Liberty Dairy Farm Facility

SECTION 4 -CONCLUSION

4.01 CONTACT INFORMATION

Thank you for providing BLD the opportunity to perform this important service requirement. BLD strives to provide leak detection services in a good and workmanlike manner with sound practices and judgements that are exercised by recognized professional firms. If you have any questions or concerns regarding the leak detection service or this report, please contact us at (210) 684-8886 or via email at info@beyondleakdetection.com. We appreciate your business and look forward for future service requirements.

Sincerely,

Harvey Moy
President, CEO and
Senior Project Manager

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